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OUTGASSING TEST FOR NON-METALLIC MATERIALS ASSOCIATED WITH SENSITIVE OPTICAL SURFACES IN A SPACE ENVIRONMENT

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ATTACHMENT

Attachment	Title
A	Micro VCM Specimen Holder

OUTGASSING TEST FOR NON-METALLIC MATERIALS ASSOCIATED WITH SENSITIVE OPTICAL SURFACES IN A SPACE ENVIRONMENT

1.0 PURPOSE

The purpose of this document is to supplement JSC specification SP-R-0022A (Vacuum Stability Requirements of Polymeric Material for Spacecraft Application) by establishing outgassing requirements and test guidelines for non-metallic materials used in the space thermal/vacuum environment in the vicinity of sensitive optical surfaces.

2.0 APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein.

SP-R-0022A (JSC)	Vacuum Stability Requirements of Polymeric Material for Spacecraft Application
E 595-77 (ASTM)	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

3.0 REQUIREMENTS

The control and verification of material outgassing to the guidelines of this document are based on the following requirements:

a. The materials used in the thermal/vacuum environment shall not contaminate the sensitive optical surfaces within an assembly.

b. The materials used in any application shall not affect the sensitive optical surfaces of any adjacent equipment.

The material shall have a maximum total mass loss (TML) of 1.0% of the original specimen mass, a maximum volatile condensable material (VCM) content of 0.1% of the original specimen mass. The optical witness sample (OWS), a magnesium fluoride coated aluminum first surface mirror, shall be within the allowable limits of vacuum UV (121.6 nm - 200.0 nm) reflectance change ($-3.0\% \ \Delta R/R_o$) when tested in accordance with the test procedure in Section 7.

4.0 SCOPE .

The scope of this document covers the control of non-metallic materials used in the vicinity of sensitive optical surfaces that are exposed to the thermal/vacuum environment of space. This document establishes the requirements and defines the test method to evaluate these materials.

5.0 SELECTION AND VERIFICATION REQUIREMENTS

Use of non-metallic materials near sensitive optical surfaces shall be restricted to those materials which have a maximum volatile condensable material content (VCM) of 0.1%, a total mass loss (TML) of 1.0% or less, and a maximum $\Delta R/R_o$ of -3.0% over the 121.6 nm to 200.0 nm wavelength range upon post-test vacuum UV reflectance analysis of the OWS.

The use of materials that have been tested but failed the requirements of this specification may be allowed if the contractor can provide rationale for their use that is approved by a Materials Usage Agreement (MUA) through MSFC.

The following are examples of some considerations for use as rationale for a material that has failed the TML, VCM or optical reflectance requirements:

a. The material may be brought within vacuum stability limits by vacuum baking for a specified period of time (usually 48 hours at maximum use temperature at a pressure of less than 10^{-6} torr). A verification test is required.

b. If the material cannot be vacuum baked and its exposed area is 13 cm^2 or less, and the material is out of line-of-slight of payload surfaces and other contamination critical surfaces, TML may be up to 3.0% and VCM content up to 1.0% if optical requirements are met.

c. If the TML is greater than 1.0% and VCM $\leq$ 0.1%, and it can be shown that contributions to the TML greater than 1.0% are due to sorbed water vapor, WVR, (See 8.0), the material may be used if optical requirements are met.

d. The total mass of materials selected under 5.b. above and used in any given compartment will be monitored and reviewed periodically to insure that compartmental peculiar problems do not evolve.

6.0 IMPLEMENTATION

The contractor shall provide for approval, a list of all materials selected for use in the vicinity of sensitive optical surfaces or in the same defined compartment as sensitive optical surfaces.

The following information is required:

a. Material manufacturer.

b. Manufacturer's trade name.

c. Maximum use temperature.

d. Thermal/vacuum stability (VCM and TML) data.

e. Temperature of optics in vicinity of the material.

f. Rationale for use of the material that failed the requirements of Paragraph 5.0 and a report of the weight and surface area used.

7.0 MATERIAL TESTING

7.1 Purpose:

The purpose of this test is to measure total mass loss (TML), volatile condensable material content (VCM), and reflectance change of an optical witness sample (OWS) due to outgassing contaminants under controlled laboratory conditions.

7.2 Test Conditions:

The test on non-metallic materials shall be conducted under the following conditions:

Temperature of Specimen	Normally 125°C (JSC SP-R-0022A) but for special cases, at least 10°C above maximum use temperature (+/-1°). (See ASTM E 595-77, Paragraph 4.5)
Temperature of Collector Plates and OWS	25°C or temperature of optics to which material is exposed (the lesser temperature +/-1°C).
Pressure	10^{-6} torr or less.
Vacuum Exposure Time	24 Hours.

7.3 Test Equipment:

All laboratory test instrumentation shall be in current calibration and shall reflect appropriate documentation from the applicable calibration laboratory. The test apparatus shall conform to critical dimensions of Table 1 (test apparatus dimensions) and Figure 2 of ASTM E 595-77. A minimum of three samples, two collector plates, and one OWS shall be included in each test.

The test equipment shall consist of the following:

a. A vacuum system capable of maintaining 10^{-6} torr for a period of 24 hours.

b. Specimen holder made of aluminum foil.

c. Collector plate made of a highly polished stable metal surface.

d. Optical witness sample holder made of aluminum and capable of holding a mirror one inch in diameter (see Attachment A).

e. A test apparatus made of copper. The apparatus shall be capable of accommodating a minimum of three samples in the heater bar, and two collector plates and one OWS holder on the cooling plate. The heater bar and cooling plate shall be capable of maintaining the samples, and collector plates and OWS, respectively, at their appropriate temperatures +/-1^{o}C.

f. A balance having +/-1 μg sensitivity for weighing samples and collector plates.

g. A reflectometer capable of making vacuum UV specular reflectance measurements over the 121.6 nm to 200.0 nm wavelength range.

7.4 Cleaning Procedures:

Cleaning and storage procedures shall be found in Annex A1 of ASTM E 595-77.

7.5 Sample Preparation:

NOTE: Specimen handling procedures outlined in Section 7.7 of ASTM E 595-77 shall be followed.

7.5.1 **Specimen size.** Materials to be tested shall be prepared in 100 mg to 300 mg specimen sizes and placed in aluminum holders after preparation as specified below.

7.5.2 **Solid Materials.** Specimen shall be cut into small pieces having 6 mm maximum dimension. Sample materials (coatings or tapes) applied to a substrate, aluminum foil or teflon sheet, for testing shall be applied to a substrate with known density so that actual sample material weight may be determined. Samples shall be placed in a desiccator after preparation and remain there until the samples are placed in the test chamber.

7.5.3 **Coatings.** Materials that are normally used as coatings shall be applied to aluminum foil or teflon sheet with known density and prepared as noted in Paragraph 7.5.2.

7.5.4 **Solvent Containing Materials.** Prior to testing solvent containing materials, such as inks and paints or room temperature cured materials, the sample shall be preconditioned for 24 hours at 65 +/-1^{o}C in an air circulating oven to simulate the material exposure up to the time of launch.

7.5.5 **Tapes.** Tapes shall be tested in the as applied configuration using aluminum foil or teflon sheet with known density as an application substrate and prepared in accordance with Paragraph 7.5.2. Actual weight of adhesive on the tape should be known. Total edge exposure length during the test shall be reported (See Paragraph 10.0).

7.5.6 **Liquids.** Liquids shall be tested in the as-received state.

7.5.7 **Cure Procedures.** All material shall be cured or applied in accordance with the manufacturer's procedures or the applicable contractor process specification prior to test.

7.6 Test Procedure:

Test procedures outlined in Section 8 of ASTM E 595-77 shall be followed except for the sample temperature and cooling plate temperature which will be determined by procedures previously defined in Paragraph 7.2 of this document.

7.7 TML, VCM, WVR, and Optical Reflectance Measurement:

NOTE: All weighings shall be made on a balance having +/-1 μg sensitivity.

7.7.1 **Initial Mass Determination.** The VCM collector plates and specimen holders shall be weighed prior to testing. All weights shall be recorded.

7.7.2 **Initial Optical Reflectance Measurement.** The vacuum UV specular reflectance [near-normal incidence ($\leq 20^{\circ}$)] of the OWS to go in test along with a control OWS shall be measured over the 121.6 nm to 200.0 nm wavelength range. For non-continuous scanning reflectometers, reflectance measurements shall be recorded at 121.6 nm, 125.0 nm, 130.0 nm, and 10.0 nm wavelength increments from 130.0 nm thru 200.0 nm. The reflectometer assembly consisting of light source, optics, reflectometer, and instrumentation shall be capable of +/-1% repeatability in measurement of specular reflectance, consistently through the period of use. All measurements shall be recorded.

7.7.3 **Final Mass Determination.** The specimen and collector plates shall be weighed as soon as possible after removal from the VCM apparatus. Specimen shall then be returned to the desiccator for 24 hours. After this 24 hours the specimen shall be weighed again to determine the amount of water vapor regained (WVR). All weighings shall be recorded.

7.7.4 **Final Optical Reflectance Measurements.** The vacuum UV specular, near-normal incidence reflectance of the test OWS and corresponding control OWS shall be measured per 7.7.2 over the 121.6 nm to 200.0 nm wavelength range. All measurements shall be recorded.

8.0 TEST RESULTS

Values for TML, VCM, and WVR shall be calculated per ASTM E 595-77, Section 9 (Calculations). Optical reflectance data shall be tabulated for quick reference.

10.0 TEST REPORT

The report of results from each test shall include the following:

(1) Total mass loss (TML)

(2) Collected volatile condensable material(VCM)

(3) Water vapor regained (WVR)

(4) $\Delta R/R_o$ maximum and corresponding wavelength

(5) Sample test temperature

(6) Optical witness sample (OWS) test temperature

(7) Sample cure conditions if applicable

(8) Sample cleaning procedure if applicable

(9) Length of edge exposure for tape samples

(10) Material acceptability determination made per Paragraph 9.0

(11) Plans for further testing if applicable, and

(12) A statement of any other relevant items which might be deemed important.

9.0 CRITERIA OF ACCEPTABILITY

The material shall have a volatile condensable material content of less than 0.1% of the original mass of the specimen. The total mass loss of the material shall not exceed 1.0% of the original mass of the specimen. Upon post-test vacuum UV reflectance analysis, the maximum negative percentage change in reflectance of the OWS referenced to the pre-test value, and normalized to control OWS values shall not exceed 3.0% over the 121.6 nm to 200.0 nm wavelength range. If these acceptance values are exceeded refer to Paragraph 5.0.

The percentage change in reflectance ($\Delta R\%$, referred to as $\Delta R/R_o$ in this document) is calculated for each wavelength, as:

$$\Delta R\% = \frac{[(R_{co}/R_{cf})R_{tf} - R_{to}]}{R_{to}}$$, where

R_{co} = Pre-test reflectance of control OWS

R_{cf} = Post-test reflectance of control OWS

R_{to} = Pre-test reflectance of test OWS

R_{tf} = Post-test reflectance of test OWS